Fast Sampling of Diffusion Models with Exponential Integrator

Year: 2022 | Citations: 516 | Authors: Qinsheng Zhang, Yongxin Chen

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Abstract

The past few years have witnessed the great success of Diffusion models~(DMs) in generating high-fidelity samples in generative modeling tasks. A major limitation of the DM is its notoriously slow sampling procedure which normally requires hundreds to thousands of time discretization steps of the learned diffusion process to reach the desired accuracy. Our goal is to develop a fast sampling method for DMs with a much less number of steps while retaining high sample quality. To this end, we systematically analyze the sampling procedure in DMs and identify key factors that affect the sample quality, among which the method of discretization is most crucial. By carefully examining the learned diffusion process, we propose Diffusion Exponential Integrator Sampler~(DEIS). It is based on the Exponential Integrator designed for discretizing ordinary differential equations (ODEs) and leverages a semilinear structure of the learned diffusion process to reduce the discretization error. The proposed method can be applied to any DMs and can generate high-fidelity samples in as few as 10 steps. In our experiments, it takes about 3 minutes on one A6000 GPU to generate $50k$ images from CIFAR10. Moreover, by directly using pre-trained DMs, we achieve the state-of-art sampling performance when the number of score function evaluation~(NFE) is limited, e.g., 4.17 FID with 10 NFEs, 3.37 FID, and 9.74 IS with only 15 NFEs on CIFAR10. Code is available at https://github.com/qsh-zh/deis